Appendix

U. S. Provisional Application No. 60/554,258

ELECTRICAL CONNECTOR FOR SEMICONDUCTOR DEVICE TEST FIXTURE AND TEST ASSEMBLY

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Provisional Application Draft

TEST FIXTURES AND CONNECTIVITY METHOD WITH TRUE SENSING AND GUARDED SIGNALS ALL THE WAY TO THE DEVICES-UNDER-TEST

(by Peter P. Cuevas)

Introduction

The electric wires connecting between the *Device(s) Under-Test* (DUT(s)) and the electronic equipment, which delivers the various electrical stimuli to the DUTs and measure them accordingly, require special attention, in particular when sensitive semiconductor and/or passive devices are involved. Since the DUTs are commonly placed on a special fixture (hereinafter "Test Fixture"), these connecting wires may develop non-negligible Ohmic voltage drop due the flowing current, as well as leakage to their surrounding (neighboring wires in particular). The stringent demands from state-of-the-art electronic device testing, in terms of accuracy, sensitivity and low-leakage current, over a wide range of current and voltage levels, make such connectivity issues both important and challenging.

The most common approach to address these concerns is by using two tri-axial cables (hereinafter "Triax") per each electronic stimulus, where both true-sensing and minimal leakage are important. The center conductor of one cable is the forcing signal, the surrounding cylindrical conducting shell is the guarding signal ("Guard"), driven by the same potential as the forcing signal, but insulated both electrically and physically from it. The outer metal shell is usually connected to ground potential for safety and also shields from outside noise (RFI). Similarly, the center conductor of the other Triax delivers the sensed signal to the high impedance measurement unit, with a similar guarding scheme and outer metal shell. Since the force and sense lines are fully enclosed by their surrounding Guards, all with almost the same potential, the leakage is reduced significantly. Also, connecting the sense to the DUT assures measurement of the required voltage at the DUT, rather than the forcing signal, possibly affected by Ohmic losses along its connecting line.

As this technique is well known and documented in the prior art (for example, Agilent Technologies 4155B/4156B Semiconductor Parameter Analyzer User's Guide General Information, page 2-38), it is obviously beyond the scope of this application. However, even with such two-Triax approach, there is a problem with the final connection within the Test Fixure. As each Triax terminates with a respective connector on the Test Fixture, the connection from this connector to the DUT is implemented with simple wires due to physical constraints (see Fig. 1). Furthermore, to facilitate connectivity to every possible pin of the DUT, a "jumper matrix", made off plug-in wires connecting between the signals and their intended destination, is needed. In all, the guarding scheme is practically broken at the connectors that terminate the Triax cables at the Test Fixture and not as close as possible to the DUT.

The following invention provides a solution to this problem, by different cables, well suited for such task, and an overall simplification of the connectivity scheme. It also

introduces a new test fixture mounted as a rotating tray, which can serve as front cover to the electronic equipment as needed. Thi eliminates the long Triax cables and the separate and remote Test Fixture altogether, while still providing the improved connectivity scheme of the invention.

Summary of the Invention

The first element in the invention is the use of miniature USB cables, very common in computer related applications. These flexible, relatively cheap, readily available and physically small cables posses excellent insulation characteristics. Each cable contains five inner wires, all surrounded by a metallic enclosure. The five inner-wires are used as follows: One wire for Sense, one wire for Guard and the remaining three wires for Force. Note that three wires are allocated for the force signal to maximize its current carrying capability; however, any combination which assures at least one dedicated wire to each of the three functions (namely, Force, Sense, Guard) is applicable and should be considered an integral part of this invention. Another related provision addresses safe handling: The outer coating along the entire USB cable is made of flexible insulator. Its only exposed part is the terminating edge which requires plug-in connection to a mating connector in the Test Fixture and, in the opposite end, to the electronic equipment via similar connector. Since these cable edges are exposed to allow good electrical contact between the outer metal and the mating connector's frame, the user may be exposed to the voltage at this outer metal before the cable is plugged into its mating connector (once plugged, everything is insulated). As the outer metal provides good noise protection and prevents leakage when used as Guard, connecting it to the Guard signal is desirable, so this safety issue must be properly addressed.

The solution is described in Fig. 2: The outer metal is not connected to any signal as long as the cable is not plugged into the Test Fixture. Once plugged, an internal connection on the insulated printed circuit board of the Test Fixture effectively shorts between the dedicated inner wire of the USB cable, carrying the Guard signal, and the outer metal. This way, only when the cable is fully plugged and the user is not exposed to its conductive parts, the outer metal is fully guarded as required.

Since the USB cable is small and its connector presents such a small foot-print, we are able to connect as many cables as needed for practical testing and well beyond that (28 for example, with straightforward expansion to 40). This eliminates the need for such "jumper matrix", as shown in Fig. 2. Furthermore, a single printed circuit delivers each and every signal to its intended DUT pin with fully guarded lines, all the way to the DUT(s).

Finally, with the simplifications described above, a novel Test Fixture is added as part of this invention. A cover to the front panel is modified to house a complete Test Fixture, with the USB wires connecting directly between the electronic box (its front panel) and the Test Fixture. This eliminates the Triax cables altogether, reduces the length of any connecting cable from several feet to about 10 inches and allows, by a handy rotation scheme, testing while the Test Fixture is open (perpendicular to the front panel), or fully closing the electronic equipment as front cover (DUTs inside).

FIG. 1

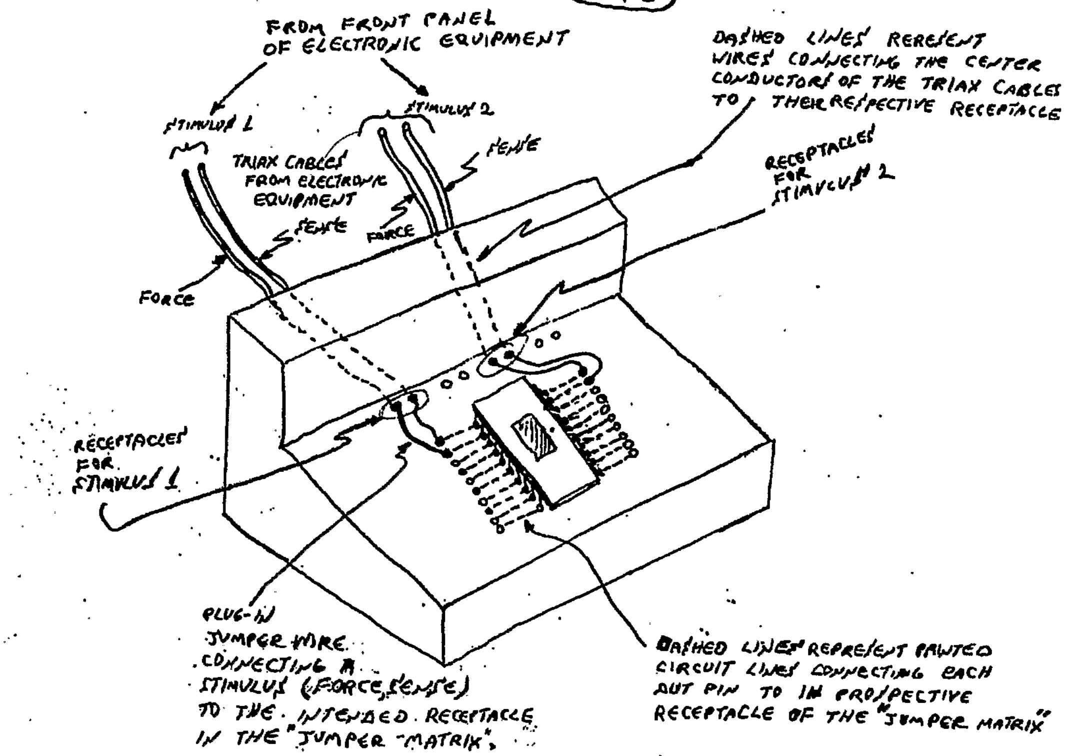
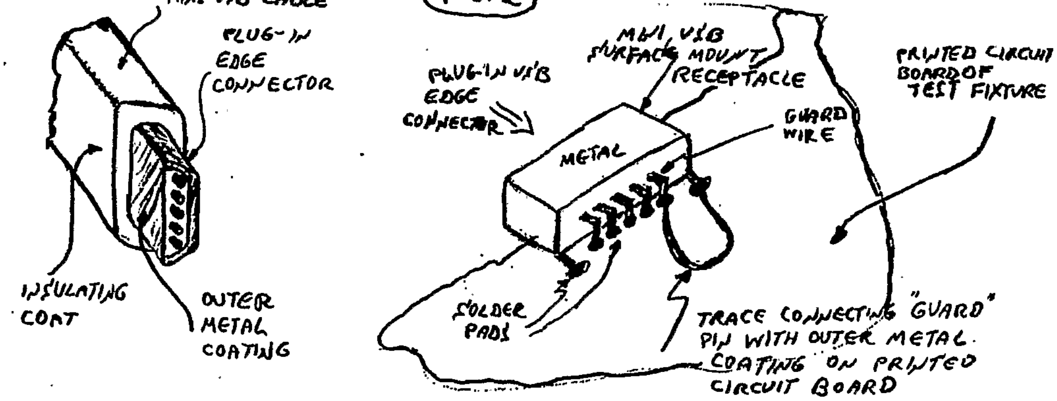

FROM FRONT PANEL OF ELECTRONIC EQUIPMENT
DASHED LINES REPRESENT WIRES CONNECTING THE CENTER CONDUCTORS OF THE TRIAX CABLES TO THEIR RESPECTIVE RECEPTACLE
STIMULUS 1
STIMULUS 2
TRIAX CABLES FROM ELECTRONIC EQUIPMENT
SENSE
FORCE
SENSE
FORCE
RECEPTACLES FOR STIMULUS 2
RECEPTACLES FOR STIMULUS 1
PLUG-IN JUMPER WIRE CONNECTING A STIMULUS (FORCE, SENSE) TO THE INTENDED RECEPTACLE IN THE "JUMPER MATRIX".
DASHED LINES REPRESENT PRINTED CIRCUIT LINES CONNECTING EACH DUT PIN TO ITS RESPECTIVE RECEPTACLE OF THE "JUMPER MATRIX"

FIG. 2


MINI USB CABLE
PLUG-IN EDGE CONNECTOR
INSULATING COAT
OUTER METAL COATING
PLUG-IN USB EDGE CONNECTOR
MINI USB SURFACE MOUNT RECEPTACLE
METAL
GUARD WIRE
PRINTED CIRCUIT BOARD OF TEST FIXTURE
SOLDER PADS
TRACE CONNECTING "GUARD" PIN WITH OUTER METAL COATING ON PRINTED CIRCUIT BOARD